Exploring Decentralized Autonomous Organizations: Towards Shared Interests and 'Code is Constitution'

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Exploring Decentralized Autonomous Organizations: Towards Shared Interests and 'Code is Constitution'

Completed Research Paper

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Abstract

In recent years, scholarly interest research on blockchain technology steadily increased. While the underlying technology matures, observed problems in the field show questions of governance to remain crucial, even though scarcely studied empirically. One approach of solving these problems can be seen in decentralized autonomous organizations, which describes a new type of organizing that is grounded on consensus-based, distributed autonomy. The governance peculiarities of DAOs is fairly unexplored, and this is where this research commences. In an exploratory multiple case study consisting of three popular DAOs Aragon, Tezos, and DFINITY, their governance peculiarities are worked out by analyzing grey literature to understand stakeholder interests, incentivization, control, and coordination mechanisms, technical considerations, and external influences from off-chain entities. In the context of an on-and-off-chain continuum, it appears that DAOs provide mechanisms that might enable autonomous decision-making but, at the same time, find themselves strongly influenced by the interests of various stakeholders.

Keywords: Blockchain Governance, Decentralized Autonomous Organizations, DAO, Open Source Governance, Algorithmic Governance.

Introduction

Blockchains like Bitcoin and Ethereum have shown their capacity to scale globally while retaining their capacity of avoiding double-spending. However, the maintenance of uniqueness of a finite number of tokens at a global scale comes at high costs. While those costs are often identified with the environmental impact of hashing, a more subtle issue is worth attention: the immutability of the ledger created fractures within the communities underpinning each blockchain. To understand reasons and modes of those fractures, this study digs into the technicalities and governance problems that a new wave of blockchains aims at tackling.

Blockchain projects, since their early days, relied on informal ways of governance resembling features of the free and open source software (FOSS) mode of organizing (Miscione et al. 2019). Blockchain governance, despite insiders' common beliefs, is not exhaustively defined by FOSS because of its peculiar reliance on the mutual dependence of several parties including system developers, system maintainers, and users, to say the least (Islam et al. 2019; Miscione et al. 2019). This mismatch between belief and practice did not go unnoticed: Bitcoin and Ethereum went through and survived several troubling forks, i.e. spin-offs of independent and incompatible ledgers. In practice, each time a problem about a blockchain arose, never-ending conflicts unfolded without the possibility of a formal authority, which was despised in the first place, to accommodate the situation (DuPont 2017). Thus, the lack of formalized rules for conflict resolution is substituted informally by charismatic leaders and heated debates, for example.

Tezos, Aragon, and DFINITY are examples of a new wave of blockchain projects, which develop decentrally-governed infrastructures to execute decentralized applications (dapps). Their governance thereby builds on principles of so-called decentralized autonomous organizations (DAOs). They try to leave the risk of 'civil wars' behind by formalizing the rules to change the rules when need arises. In short, if the first generation of blockchains formalized consensus maintenance among unknown parties, this second generation aims at formalizing the rules according by which consensus rules can be changed. Those rules are enacted by these blockchains, thus the common term of 'on-chain governance'. With an analogy that is as catchy as inaccurate, one may say that, instead of 'Code is Law' (Lessig 1999), meaning software has a regulatory function like laws, those blockchains aim at 'Code is Constitution' to the extent that constitutions contain passages that define how powers are divided, and how regulations are agreed upon before being enforced.

Several researchers call for research on DAOs, especially in decomposing their actual structures and applied governance mechanisms (Beck et al. 2018; Rossi et al. 2019). This research attempts to address this research gap by carrying out an exploratory multiple case study. The cases of Bitcoin and others have shown the fragility of a shared interest between quite diverse actors. To this end, DAOs promise to do better by applying advanced governance mechanisms while minimizing human intervention; in how far these overcome the issues highlighted by previous blockchains is a research gap with important practical implications. In this study, three DAOs with overlapping goals but varying technical solutions, namely Aragon, Tezos, and DFINITY, are examined. We thereby follow a three-step process: first, we introduce each case by depicting the DAOs' organizational and technological structure and brought-forward concepts. Second, we create an understanding on how these DAOs are governed by examining their governance systems (Albers 2019) in terms of applied/envisioned coordination, control, and incentive mechanisms. Lastly, we discuss our empirical observations against their aspired goals and associated concepts such as institutionalism (North 1990) and generativity (Zittrain 2006). Considering the latter, the understanding of the governance systems of these relatively specific types of organizations, and its contextualization to associated concepts help to comprehend current evolutions in blockchain governance. Narrowing it down, our focus is on:

RQ1: How are Aragon, Tezos, and DFINITY governed in terms of coordination, control, and incentivization?

RQ 2: What can we learn from Aragon, Tezos, and DFINITY in regard to blockchain governance?

This paper is organized as follows: we introduce related concepts of online governance and its links to blockchain governance in the next section, followed by a description of our methodology. Then, we introduce our cases and detail their coordination, control, and incentivization mechanisms one by one, which answers RQ1. Within the discussion section, we relate findings from our cases to the wider frame of existing literature about blockchain governance to answer RQ2. We conclude this paper by outlining limitations of our research and potential avenues for future research.

Related Work

Within this section, we first introduce related work on modes of governance. In subsequent steps, we then introduce central terminology for this paper and show the evolution of blockchain governance over time. We conclude this section with a description of the lens which we applied to analyze our DAOs.

Modes of Governance

Building up on new institutional economics, modes of governance are classified into markets, hierarchies (Williamson 1975), and networks (Powell 1990). Markets and hierarchies relate to internalizing/externalizing activities depending on transaction costs measured in asset specificity and transaction frequency. These are seen, broadly speaking, through the lens of control (evaluation against goals), incentive (monetary/non-monetary), contracting (modality of arrangement) and coordination (division/alignment of work) mechanisms. The network extends this dichotomy with a relational view of actors with a shared goal. Within these three, actions are determined by price and free choice (markets), bureaucratic control and authority (hierarchy), or reciprocity and mutual consensus (networks). As Miscione et al. (2019) argue, which is in line with other researchers (Beck et al. 2018; Demil and Lecocq 2006), these modes of governance are limited means to explain the online modes of governance as seen, among others, in wisdom of the crowds (Surowiecki 2005) or generativity (Zittrain 2006), but also on FOSS. FOSS, as an instance of commons-based peer production (Benkler 2017), is characterized by informal ties among actors, open licenses, no central steering entity, and forks of software (Demil and Lecocq 2006). In contrast to markets, network, and hierarchies, FOSS' open license limits rent seeking from property rights (thus undercuts market governance), relational contracting is hindered due to anonymity (network), and its "structurelessness" (Freeman 1972) – meaning the absence of formal structures – turns bureaucratic control unfeasible (hierarchy), to say the least. Even if blockchain technology finds its origins in FOSS, the unlimited replicability renders the FOSS governance mode insufficient for blockchains as we will argue below. Furthermore, several researchers (Allen et al. 2020; Davidson et al. 2016; Meijer and Ubacht 2018) see blockchains as new institutional technology, which compete with markets, hierarchies, and networks as more efficient ways of governance. Within this research, we define governance as the ability to get actors to behave as they would not in pursuit of an agreed-upon goal (Miscione et al. 2019).

Blockchain Governance: Fundamentals and Foci

This paper studies blockchain governance, so technical details are only introduced to the extent that they are relevant. Blockchain systems are herein understood as blockchain applications and their organizational embedment (Ziolkowski et al. 2020). Broadly speaking, blockchains rely on the principles of decentralization (no central authority), persistency (transaction immutability), auditability (traceability of events), and anonymity (key pair authentication) (Zheng et al. 2017). They can be broadly classified along two axes: access to transactions and transaction validation rights, which leads to either *public* (public transactions, everyone can validate), *permissioned* (public transactions, restricted validation), or *private* (private transactions, restricted validation) blockchains (Peters and Panayi 2015). The most common type to date are public blockchain systems, such as Bitcoin (DuPont 2017). Miscione et al. (2018) characterize their governance as "tribal", in which actors coordinate in loosely defined groups with shared values and interests. When interests diverge, members of a tribe branch out (forking) and create their own tribe (fork).

Several researchers see blockchain governance from the two different foci *of* and *through* (De Filippi and Mcmullen 2018; Miscione et al. 2018) and enacted in the two different modalities of *on-* and *off-chain* (De Filippi and Mcmullen 2018; Reijers et al. 2018) (see table 1). Off-chain governance describes decision-making procedures and rules that are not directly encoded (Reijers et al. 2018), e.g. stakeholders arrange blockchain-agnostic communication to find consensus. Reijers et al. (2018) define on-chain governance as a set of rules and processes, which are directly encoded into the blockchain system, leading to ex-ante agreed-upon decision-making procedures. Its benefit is also said to be its disadvantage (De Filippi and Mcmullen 2018): on-chain governance rules are deterministic but fail to respond to unexpected situations. This opens a loophole for reintroducing off-chain governance, which is inherently vague and can cause centralization in a field that is pervaded by the belief of decentralization (De Filippi and Mcmullen 2018).

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Modality</td></tr>
<tr><td>On-chain
Blockchain-inherent</td><td>Off-chain
Blockchain-agnostic</td></tr>
<tr><td rowspan="2">Focus</td><td>Governance of blockchain
Focus: Blockchain system</td><td>Blockchain-inherent components that facilitate the governance of the blockchain system.
Examples: transaction validation system, built-in incentive schemes</td><td>Blockchain-agnostic components that facilitate governance of the blockchain system.
Examples: system-centric decision-making in online communities or legal bodies</td></tr>
<tr><td>Governance through blockchain
Focus: Use-Case</td><td>Blockchain-inherent components that facilitate governance of the blockchain use-case.
Examples: governing a monetary system through a blockchain system</td><td>Blockchain-agnostic components that facilitate governance of the blockchain use-case.
Examples: use-case-centric decision-making in online communities or legal bodies</td></tr>
</table>

Table 1. Governance Foci and Modalities

Blockchain Governance: From FOSS and "Code is law" to "Code is Constitution"?

FOSS principles are commonly adopted in the blockchain domain (Miscione et al. 2019), e.g., decentralization, or forking and adapting own versions of software. Differently from FOSS, however, core actors need to find agreement on how to advance blockchain systems (Ziolkowski et al. 2018). Governing blockchain as FOSS showed its limitations: Having no entity formally in charge nor procedure to appeal to, decision-making processes were often painfully complicated and ineffective, leading to crises threatening the "tribe" (De Filippi and Loveluck 2016). As anticipated already decades ago (Freeman 1972), "structurelessness" does not translate into the absence of structures, which applies to both FOSS and blockchains: Zheng et al. (2017) found Bitcoin to be centralized in mining power and code development. While influential figures, usually from the software development side (e.g., Vitalik Buterin for Ethereum; Linus Torvalds with Linux), emerge, their influence in blockchains is counterbalanced by miners and users (Ziolkowski et al. 2018). Aware of these shortcomings, blockchains revived the "Code is law" mantra (Lessig 1999), from which the case of TheDAO[1] emerged, in which smart contracts gained centrality. Smart contracts originated over two decades ago (Szabo 1997), and, in layman's terms, represent encoded (hence, immutable) and autonomously-enforced business logic (Gatteschi et al. 2018), promising lower transaction costs through automation while substituting human with algorithmic agency (Murray et al. 2019). Automation, however, requires determinism in inputs, evaluation criteria for these inputs, and outputs. This renders smart contracts appropriate for routine but inappropriate for non-routine tasks with unknown unknowns (Gatteschi et al. 2018). This last issue is well-exemplified by the TheDAO failure, as third parties had to step in as mediators (DuPont 2017).

The two approaches shown before, one led by limited coordination and control, the other by unstoppable automation, have shown limitations. Miscione et al. (2019) formulate two ways forward: Either, (1) blockchain communities push 'code-is-law' further ('Code is Constitution'; focus on on-chain governance), or (2) external control (e.g. foundations, consortia) has to be reintroduced. This study focuses on the former: DAOs rely on decentralized collaboration, internal control, and autonomy (De Filippi and Mcmullen 2018). While smart contracts aim to be a DAO's backbone, human involvement is formed by off-chain governance bodies and processes; users are thereby also divided along held tokens (often bound to voting power) or expertise (Raval 2016). This re-instantiates the relevance of trust in these systems, which have repeatedly been considered "trust-free" (Beck et al. 2016; Jarvenpaa and Teigland 2017). As several other researchers argue (Miscione et al. 2019), this stance may be misleading as trust in both developers – that the system is designed properly – and the maintainers – assuring the well-functioning of the systems – has to be ensured, to say the least.

Studying DAOs through the Lens of Coordination, Control, and Incentivization

What makes blockchain, and hence, DAO governance peculiar is a mutual dependence of actors to operate, maintain, and adjust its system (Islam et al. 2019; Miscione et al. 2018). As the previous section has shown, this mutual dependence has been governed in various forms up to date. To understand the novel approaches of governance brought forward by DAOs, we utilize a lens, which Albers (2019) labeled the governance system. As Albers argues, the purpose of the governance system – allocated between governors and governed – is to ensure that desired goals are met by utilizing the governance mechanisms of coordination, incentivization, and control upon involved actors (Albers 2019, p. 72). Thereby, we follow Ouchi's (1979) definition of governance mechanisms, which are applied to an organization to assure its achievement of goals. We define coordination in a wider sense as the division of labor into tasks, assignment to actors or groups, and the tasks' goal-oriented, ongoing alignment to assure the completion of an activity (Mintzberg 1979), control as the process of monitoring and measuring performance of an actor regarding a given task (adapted from Albers (2019), based on Baliga and Jaeger (1984)), and incentivization as means to alter an actor's or group's willingness to engage in specified behaviors (Albers 2019) (see table 2 below). As we will argue in the following, each of these governance mechanisms found relevance for the blockchain domain.

As for **coordination**, several researchers studied the roles of responsibilities of actors in blockchain networks, which depend on the blockchain system type (Islam et al. 2019), and the way they align their

[1] TheDAO: the largest crowdfunding project at its time. A bug in a smart contract caused the loss of a significant amount of its funds. The discussion on how to proceed – reverting the malfunction or living with the consequences of lost funds – caused heated debates, resulting in a fork of Ethereum's community into Ethereum Classic (DuPont 2017).

work (DuPont 2017; Hsieh et al. 2018). Broadly speaking, these include system designers and maintainers (token-owners), who have to achieve consensus on the transactional (validation/integrity of transactions), technology development (maintaining/altering the system), and organizational (meta-rules/governing stakeholders) layer (adapted from Hsieh et al. (2018)). As for the modality of coordination, Mintzberg (1993) defined the three coordination mechanisms of mutual adjustment, standardization (of skills, work processes, or outputs), and direct supervision. Different from firms (contracts and authority) or networks (relational contracts and reciprocity), but similar to FOSS, actors coordinate and align work in blockchains often informally via repositories or online communities, which proved inefficient for blockchains (De Filippi and Loveluck 2016). As depicted above, smart contracts emerged as a coordination mechanism as they standardize work processes, which TheDAO exemplified with the process of funds coordination. To reveal explicit structures of these DAOs, also in regard to the actual degree of their decentralization which is bound to power (Rossi et al. 2019), it is necessary to decompose core actors, their tasks, and points of alignment.

As for **control**, blockchains employ various control mechanisms to assure that undertaken actions comply with mutually agreed goals. While control on the transactional layer is inscribed in blockchain protocols, control mechanisms on the technology development or organizational layer can be considered rather informal: On the technology development layer, as seen in Bitcoin, so-called Bitcoin Improvement Proposals serve as a checkpoint for review by experienced developers for quality and fit (De Filippi and Loveluck 2016). It is important to note, that the presence of values is strongly reflected in these, which is well-exemplified in the controversy around Bitcoin's block-size[2]. To exercise control and, for example, deal with unforeseen events, to act as a supervising entity, but also to create a common point of reference, several larger blockchain projects like Bitcoin or Ethereum founded off-chain governance bodies (associations/foundations). This is in line with calls for enacting accountability (hence, control) in general technically – via smart contracts –, but for unforeseen cases, institutionally (Beck et al. 2018). Hsieh et al. (2018), on a similar line, also see limits in the applications of DAOs when DAOs exceed the realm of FOSS, as control structures then have to protect mutual interests, which is evident in the rising number of blockchain consortia (Gratzke et al. 2017). Similarly, Meijer and Ubacht (2018) see blockchains as multi-agent systems, to which Hsieh et al. (2018) agree, and they study tensions among control and trust in these.

As actors of a blockchain systems are mutually dependent, means to foster certain behavior of actors emerges as a crucial component. The blockchain domain already knows various types of these **incentive** mechanisms, such as monetary ones for system maintenance (mining fees) or user engagement (airdrops/participation rewards), but also non-monetary mechanisms such as reputation for software contributions, as well as praise, status, or wider recognition within one's community. In presence of values led by decentralization, also the meaningfulness of one's job and, consequently, altruism are important facets of incentivization. Consequently, Beck et al. (2018) see incentivization as the backbone of blockchain systems to deal with the actors' behaviors and, hence, their mutual interests.

Drawn from the previous arguments, modes of governance in blockchain systems differ from common modes of governance due to their mutual dependence. It remains unexplored, how coordination, control, or incentivization mechanisms are utilized in DAOs, especially regarding foci or modalities (table 1), which are strongly bound to distribution of power. This demands exploration in the field.

Mechanism Category	Governance Mechanism and included concepts	Relevance for Blockchain Systems
Coordination Division of labor into tasks, assignment to actors or groups, and the tasks' goal-oriented, ongoing alignment to assure the completion of an activity (Mintzberg 1979)	Based on Mintzberg (1979, 1993) **Mutual Adjustment:** negotiation/bargaining, liaison devices **Direct supervision:** authority/fiat **Standardization of** … … **work processs:** rules and regulations, standard operating procedures … **outputs:** planning and control … **skills:** training, indoctrination (culture)	Blockchains are organizationally and technically decentralized; how is work divided and aligned? (Rossi et al. 2019) Similar to FOSS, blockchains coordinate informally through repositories/online communities, which proved inefficient (De Filippi and Loveluck 2016) Smart contracts emerge as coordination mechanisms as they standardize work processes (e.g., TheDAO in terms of fund coordination)
Control Process of monitoring and measuring performance of an	Based on outcome measurability (OM) and task programmability (TP) (taken from Albers (2019); based on Eisenhardt 1985):	On transactional layer inscribed into blockchain protocol; on technology development layer, improvement proposals are points of control for stakeholders (De Filippi and Loveluck 2016).

[2] Simplified: allowing for a higher transaction throughput, which would Bitcoin make suitable for payments; mining would become more expensive for node holders with a comparably low hash rate, which would foster centralization (De Filippi and Loveluck 2016).

actor regarding a given task (adapted from Albers (2019), based on Baliga and Jaeger (1984))	high OM, high TP: **formal behavior or outcome control** high OM, low TP: **formal outcome control** low OM, high TP: **formal behavior control** low OM, low TP: **informal behavior or outcome control**	Values strongly influence against what is measured (see Bitcoin-Scaling-debate) Off-chain control is increasingly institutionalized in the form of associations, which also introduces (partly) accountability (Beck et al. 2018)
Incentivization Means to alter an actor's or group's willingness to engage in specified behaviors (Albers 2019)	**Nature of incentive:** material vs. immaterial **Basis of provision:** subjective vs. objective **Reference unit:** group vs. individual	Blockchain systems are at least dependent developers, maintainers, and third parties (users, wallet providers etc.); incentivization crucial to deal with actors' mutual interests (Beck et al. 2018). Several monetary incentivization (mining fees / airdrops/ participation rewards) but also non-monetary rewards (reputation/praise) are crucial in blockchain systems.

Table 2. Governance Mechanisms, adapted from Albers (2019)

Methodology

This research is embedded in a multi-year and multi-researcher study to explore blockchain governance, with this paper focusing on DAOs. To understand their peculiar governance configurations against the theoretical background shown above, an exploratory multiple case study covering three exemplary major DAOs, namely Aragon, Tezos, and DFINITY, was initiated. These were chosen for their size and relatively long life span, which we expected would correlate with maturity and use. Secondly, albeit they share the common trait of deploying forms of on-chain governance, they functionally differ in scope and architecture. This allowed us to study on-chain governance in different contexts. Our overall methodology follows the approach proposed by Kuckartz (2013), which we synthesize as follows: (1) collection of data, (2) codebook development, (3) data analysis, and (4) results evaluation. We detail these steps in the following.

Collection of data. Tezos, DFINITY, and Aragon gained a lot of attention from the mainstream media and, consequently, there is a plethora of grey literature but almost no academic references. Hence, the cases' publicly available whitepapers, reports, and newspaper articles were central to our empirical study. To retrieve data about these cases, the starting point was each project's official website, its individual sections, and linked documents. While the former have been our primary source for information, we also included specialized press such as Bloomberg, Forbes, Coindesk, and Medium; the latter has frequently been used by spokespeople of these projects as a channel to announce news on, e.g., the state of their development, changes in their roadmaps, or educational purposes. We utilized these statements, among others, as credible inputs to carve out the state of the art of their development and its drifts from its targets in their project descriptions. The choice to rely on a variety of sources close to these projects was important to ensure a credible depiction of these cases. Overall, our data collection has been conducted from spring to fall 2019 and comprises 116 documents.

Codebook Development. In developing an appropriate lens to study the mode of governance of DAOs, we relied on an up-to-date literature basis which informed our case study's overall design in generating an appropriate coding framework. Our coding framework, which was theoretically informed by the modes of governance introduced above in the 'related work' section, consists of 131 codes, organized on four levels of detail. Our codes center around the key categories of (1) general attributes, such as technicalities (e.g., ledger technology, protocols, stacks, consensus algorithms), organizational composition (e.g., on-/off-chain processes, internal/external stakeholders, IP-holders), and history (e.g., what has been implemented), (2) meta-codes (e.g., challenges, positive/negative effects, on-/off-chain), (3) and governance-specific codes (e.g., incentivization, coordination, control, contractual framework). To ensure the fit of our theoretical stance with our empirics, we relied in our framework development on both deductive (informed by theory) and inductive (raised by empirics) codes. Continuous improvements, additions, merging, and deletions of categories and codes were enacted throughout our research for an appropriate quality of our data analysis.

Data Analysis. To understand our cases in-depth, we applied our codebook to our data using a software for qualitative data analysis (MAXQDA) with several goals in mind. For one, for each case, thorough overviews along the dimensions of the codebook were created; as chapter two depicted that organizational processes are also ingrained on technical layers in blockchains, a sole assessment of organizational or technological aspects would have not sufficed. These overviews served as a basis to derive key insights per code category, which were gathered, and eventually compared along all three DAOs to assess similarities and differences; these were also evaluated in the next step. For two, our observed cases vary in maturity and use, and their future promises pass unseen if only their status quo is considered. Hence, we decided to examine both their status quo and their planned outcome, together. From a historical perspective, this comparison was also motivated by the search of inhibitors to becoming decentralized and autonomous. For space limitations, our result section shows only parts of the results of our data analysis.

Evaluation of Results. To not rely solely on grey literature, we initiated an internal and external sense-making process to discuss and validate our findings. As for the former, initial findings have been made available and discussed within our research group, also against observations of general developments in the DAO ecosystem. As for the latter, we decided to conduct four targeted, complementary semi-structured interviews (Myers and Newman 2007) with DAO experts, which were transcribed for coding. These were helpful to validate our findings and to explore the evolution of blockchain governance in our three observed cases and beyond. The interviews were conducted either face-to-face or via Skype and all relied on a common interview guide. Finally, we derived general statements on governance traits appearing in all cases (validation), case-specific statements (validation), and meta-considerations for all DAOs (exploration).

Findings

In the following, each case is first introduced and second related to its governance traits in terms of coordination, control, and incentivization (see 'related work'). The latter are also divided into each projects' current state of development and planned outcome. For reasons of space limitations, the case descriptions are simplified and shortened to the extent that they are necessary for our argument. Further, we only reference central articles to the cases and sources other than the projects' or their spokesperson. A complete list of utilized sources can of course be provided upon request.

Overview on Aragon: Building a Self-Governed Digital Jurisdiction

Launched in 2017 after a fundraising accumulating approximately $25M[3], Aragon is an application built on the Ethereum blockchain serving as a framework for the development of other DAOs. It is led by the motif of an opt-in jurisdiction to simplify interactions between peers by facilitating functions like fundraising, voting, payments, or bylaws. While the number of DAOs built with Aragon seems impressive (539), their activity per day is found to be low to date (2-15)[4]. Aragon consists of several major parties to maintain and adjust its system: (1) its association (non-profit; oversees operation/developments, holds funds/major IP rights, employs for-profit development teams via grants, anchor to legislation), (2) Aragon Labs (non-profit; R&D entity to advance Aragon's governance), (3) the Aragon Network (actual technological network; consisting of DAOs, dapp providers, and users), and, which holds true for all observed cases and resembles FOSS, (4) free but also professional (e.g., Aragon One) software developers contributing to the project. As for Aragon's functioning[5], Aragon matches service (dapp) providers and service consumers. Aragon foresees a sustainable financing model, which compensates both dapp and Aragon as infrastructure provider: in exchange for using a service, a consumer reimburses the service provider, which then deducts a percentage of their income as a tax to the Aragon network for infrastructure provision. In return for the service providers' activity, Aragon mints (contrary to mining) and assigns them Aragon Network Tokens (ANTs), which can be used, for example, to vote on change proposals of the Aragon Network; this mechanism assures that decision-making say (number of tokens) aligns with a party's popularity. To assure smooth operations, Aragon plans two on-chain features to overcome known blockchain problems: (1) a conflict resolution system called "digital jurisdiction"[6], and (2) a coordinated way for system development and maintenance, utilizing "Aragon Governance Proposals" (AGPs) within the AGP Process[7] (AGPP).

[3] https://icobench.com/ico/aragon

[4] https://bravenewcoin.com/insights/aragon-price-analysis-robust-dao-infrastructure-remains-waiting-for-users

[5] Retrieved March 29, 2019, from https://blog.aragon.org/introducing-the-aragon-network-20b998e2caba/

[6] Digital Jurisdiction: in case of a conflict, the plaintiff opens a case, submits supplementary information, and posts a bond (disincentive for unnecessary submissions). His case is then iteratively reviewed by random, a wider array, or top judges of the Aragon network, in case the plaintiff does not agree to proposed outcomes, while placing a higher bond each time; the final outcome is binding. Kärki & Aragon (2017), retrieved March 29, 2019, from https://blog.aragon.org/aragon-network-jurisdiction-part-1-decentralized-court-c8ab2a675e82/

[7] AGPP: (1) a submitted AGP is classified in regard to its urgency and what part of Aragon it concerns (e.g., changes to the Association). Then, the AGP proposer pursues feedback from the Aragon community. If positive, the proposer details his AGP, which is judged by Aragon users. Upon fit, the Aragon Association assesses the AGP on defined criteria and values; if rejected, the AGP is moved back to the previous stage. If

Governance Traits of Aragon

Coordination. To understand, how work is formalized, divided, and aligned in Aragon, we detail its actors along the transactional, technology development, and organizational layer as defined in the 'related work'. Within the status quo, as for the transactional layer, block creation and validation are coordinated by Ethereum. Ethereum also coordinates the technology development layer, meaning alignment among validators and developers. However, users of Aragon naturally participate in decision-making within Ethereum, as an Ethereum-based token is utilized in Aragon. Consequently, on both layers, Aragon depends on Ethereum's technical choices[8]. As for the organizational layer, meaning the coordination among all stakeholders, Aragon's own association inheres a central role. This role is especially present in the direct supervision of the technical development with its two for-profit development teams Aragon One and Autark (both of which are off-chain entities). Their collaboration is formalized by, as we assume, bilateral (off-chain) contracts; Aragon's association is also the central point of coordination for independent developers and Aragon Labs. A central coordination mechanism on the organizational layer is the AGPP (currently off-chain), which utilizes tokens and stage-cycled proposal voting to obtain, evaluate, and decide upon proposals to alter or enhance the current system. Within the AGPP, the sequence of steps as well as their outputs are standardized (in terms of processes and outputs). Also, disputes of any kind are currently resolved with help of the Aragon association.

The status quo showed the entanglement of various off-chain parties and contracts to which several changes in the planned outcome are foreseen on its organizational layer. First and foremost, Aragon's long term plan is to widely dissolve its association, so that the network can coordinate itself utilizing the on-chain AGPP, which is supposed to minimize off-chain influence on on-chain decision-making. Users of Aragon will also coordinate interactions among themselves using so-called Aragon Agreements, which are directly bound to Aragon's jurisdiction (both on-chain). Both, the Aragon jurisdiction as well as Aragon Agreements constitute a standardization of work processes and outputs, which formalize previously informal processes.

Control. In the following, we examine Aragon's transactional, technology development, and organizational layer to understand, how control is exercised by whom within Aragon. On the transactional and technology development layer, Ethereum's Proof-of-Work algorithm controls the integrity of entries in the blockchain. As for the technology development and organizational layer, the Aragon Association inheres a strong controlling function. For example, the Aragon Association is involved in a later stage of the AGPP, where it evaluates – and eventually decides – upon proposed proposals, acting as a content filter. The Aragon Association thereby controls, if a proposal complies with the so-called Aragon manifesto[9] (control objective), which relies on values such as decentralization and self-sovereignty of individuals and organizations. These values are not only relevant for the AGPP, but Aragon's Association also evaluates other activities against these, such as funding for initiatives within Aragon Labs or in its task to oversee Autark's or Aragon One's development[10] – aside from the regular control of the software development process and software quality. But not only the Aragon Association actively controls: within the AGPP, in its earlier stages, proposals are reviewed by experienced users or developers to assure it to comply with Aragon's values and technological possibilities[7]. For last, the Aragon Association serves as a (off-chain) point of reference in case of disputes within and outside the network and acts thereby as a mediating entity.

The status quo shows that control, aside from the transactional layer, is mainly exercised by off-chain entities. Within the planned outcome, it is foreseen to shift control into the network (on-chain). There are two main pillars for this endeavor: for one, the digital jurisdiction strives to encode the conflict resolution process with a sequence of steps, in which a plaintiff's proposal is iteratively reviewed against (encoded) contractual terms by experienced Aragon users; the iteratively increasing bond to be paid by the plaintiff serves as a control mechanism against unnecessary proposals. For another, it is planned to assign Aragon's

approved, the AGP will be part of a reoccurring vote cycle. Lastly, the Aragon community decides upon the AGP; if approved, the AGP will be deployed for execution; if rejected, the AGP moves to the proposal stage or will be erased by its author. The AGPP as is currently in the process of being reworked: https://aragon.org/blog/evolving-aragon-network-governance

8 Due to conflicts with Ethereum, Aragon announced its own chain: https://techcrunch.com/2020/02/19/tim-draper-puts-1m-into-the-aragon-blockchain-project-to-create-digital-courts/

9 Retrieved March 29, 2019, from https://blog.aragon.org/the-aragon-manifesto-4a21212eac03/

10 Decentralizing Aragon's development. Retrieved March 29, 2019, from https://blog.aragon.org/decentralizing-aragons-development-5062fd6d135d/

assets, which are currently held by the Aragon Association, to the network; by that, the Aragon network becomes responsible for evaluation of stakeholder activities against shared beliefs or contractual terms.

Incentivization. As argued in the section 'related work', the shared interest between developers, miners, and users that blockchains bring about make incentivization prominent, and we study these in the following on the transactional, technology development, and organizational layer. As for the transactional layer, miner of Ethereum are monetarily incentivized to contribute their hashing power to the network for a token in return. Within the technology development layer, Ethereum developers have either monetary (grants within the Ethereum community) or reputational incentivization to contribute to the development of Ethereum. Within the organizational layer, members of the Aragon Network have two main incentives: (1) gathering ANTs as a speculative financial asset and (2) having the power to participate in the decision-making AGPP process to assure mutually beneficial outcomes are reached. The incentive to advance the system in a positive way is thereby interrelated with the value of its token. Even though for-profit development companies follow monetary incentivization, their well-being also depends on Aragon's.

As for the planned outcome, several changes in regard to incentivization mechanisms are planned. The transactional and technology development layer lie outside of Aragon, so these remain unchanged. As for the organizational layer, to finance the platform, a service supplier has to pay a certain fee to the Aragon Network for each transaction and receives minted ANT in return; as its revenue stream is based on volume of transactions, Aragon relies upon monetary incentivization to scale its network. Thus, a reliable and secure infrastructure for fast transaction processing is the main interest for both Aragon and service providers.

Overview on Tezos: Towards A Digital Commonwealth

Tezos started in 2014 and gained prominence with its record-breaking fundraise of $232m in 2017[11]. Similar to Aragon, Tezos provides a framework to create and run decentralized applications, while proclaiming itself *the last blockchain,* led by the promise of being a self-amending blockchain and offering on-chain tools to do so. While on-chain activity seems to be slowly increasing[12], we were not able to identify any live dapps, yet[13]. Unlike Aragon, Tezos implemented an own blockchain consisting of several protocols[14], which is said to facilitate change over time. Tezos utilizes the liquid Proof-of-Stake (LPoS) consensus algorithm, whose design follows the rationale that users would not hurt the system they hold equity over, where so-called bakers validate transactions[15]. A core governance process is called the amendment process, which coordinates and controls the developments of Tezos[16]. As for its organization, Dynamic Ledger Solutions (DLS) used to be a central organization founded by Arthur and Kathleen Breitman, two central figures and early contributors to Tezos. After advances of Tezos, the Breitmans founded the Tezos Foundation located in Switzerland. The Tezos Foundation impacts the network by incentivizing and selecting appropriate grantees and creating a competition between them. Tezos became famous for public feuds beginning in late 2017[17], which led to lawsuits against DLS claiming Tezos to have performed an unregistered securities sale. As a consequence, Tezos Ltd. was founded to take over the management of the Tezos Foundation.

Governance Traits of Tezos

Coordination. To understand, how tasks are formalized, divided, and aligned in Tezos, we detail its actors along the transactional, technology development, and organizational layer in the following. Within the

[11] https://www.coindesk.com/232-million-tezos-blockchain-record-setting-token-sale, accessed September 2nd, 2020
[12] https://bravenewcoin.com/insights/tezos-price-analysis-technicals-turn-neutral-despite-continued-and-sustained
[13] Overview on Tezos projects: https://tezosprojects.com/
[14] https://learn.tqtezos.com/files/whitepaper.html
[15] Tezos (LPoS) lets random stakeholders (bakers) create (bake) blocks, which is notarized by 32 other bakers. The number of XTZ (Tezos' token) held by a baker influences his chance to create the next block, block production reward and transaction fees included. As the entry barriers to become a baker are relatively high (minimum number of tokens, around 10.000 XTZ at the time of writing), Tezos allows for delegation of tokens to another party. By that, the token holders delegate not only XTZ but also trust to the baking peers and receive a partial compensation in return. Since the baker's own token deposit has to be (simplified) ~8.25% of all delegated tokens, the share of the own deposit increases with the continuous delegation of tokens, as does the incentive to bake fairly and validly. Based on: https://medium.com/tezos/liquid-proof-of-stake-aec2f7ef1da7. Retrieved April 08, 2019
[16] Four phases consisting of: the (1) Proposal Period (proposal for amendment and initial vote), (2) Exploration Vote Period (proposal discussion and vote), (3) Testing Period (proposal is implemented and tested in a sandbox), and (4) Promotion Vote Period (final vote upon implementation). Tezos thereby defines various minima for voting participation, which is weighted on past voting participation. One whole run-through lasts approximately three months. If any proposal is rejected, it is moved back to the Proposal Period. This governance approach happens directly on the blockchain. Based on: https://medium.com/tezos/liquid-proof-of-stake-aec2f7ef1da7. Retrieved April 08, 2019
[17] https://fintechnews.ch/blockchain_bitcoin/tezos-foundation-president-step-back-soon-things-track/15526/

status quo, as for the transactional layer, Tezos' LPoS algorithm coordinates block creation and validation in accordance to the agreed-upon protocol. This task includes also the coordination of mining rewards to bakers and to non-bakers, who delegated their stake to bakers. As for the technology development layer, developers and validators, same as other stakeholders on the organizational layer, utilize the amendment process for proposals to maintain or alter the system. This is significant because it allows bakers to propose fundamental changes across layers, for example, changes to the consensus algorithm and consequently the underlying logic of coordination on the transactional layer. Similar to Aragon's AGPP, the amendment process' sequence of steps as well as their outputs are standardized (in terms of work processes and outputs). While the latter is already implemented on-chain – so proposals are formalized – also, so we assume, off-chain bilateral contracts between the Tezos Foundation and for-profit engineering teams exist. These contracts arise either by the foundation's mandate or via accepted proposals within the amendment process that cannot be easily implemented. In the case of a mandate, the foundation coordinates and supervises the engineering teams' development, which proves its central coordinating role.

The status quo has shown, that, while Tezos' main coordination mechanism is already implemented, off-chain entities and conventional contracts are still utilized. As for the planned outcome, the largest change affects its organizational layer. Similar to Aragon, Tezos strives to marginalize off-chain influences on on-chain decision-making. Unlike the Aragon Association, however, the Tezos Foundation does not seem to have strict plans with fixed milestones for its evolution. Rather, it pursues an overall strategy of decentralization, so that the amendment process would act as a central coordination mechanism.

Control. Here, we examine Tezos' transactional, technology development, and organizational layer to understand, how control is exercised by whom within Tezos. On the transactional layer, Tezos' LPoS algorithm controls the integrity of entries of its ledger. Furthermore, it is inscribed into the protocol, that a baker, to whom tokens were delegated from non-bakers, has to contribute (simplified) 8.25% of all delegated tokens in own funds as deposit. This acts as a control mechanism to bake fairly, as the own deposit and prospective mining rewards are lost in case of misbehavior. As for the technology development and organizational layer, there are two things worth noting: for one, the amendment process also inheres a strong controlling next to its coordinating function. Here, development proposals are iteratively reviewed, voted upon, and eventually tried out on a Testnet, before being considered as an amendment to the Mainnet. Users control mutually, if a proposed development works as intended, and, if it complies to Tezos' values. This control mechanism also counters possible malicious actions of whales (individuals/groups possessing a significant amount of one specific token). For another, the Tezos Foundation controls ongoing development of the development bureaus against agreed-upon goals in terms of functionality and quality and distributes grants and controls their development to interested parties in enhancing the Tezos network.

The only difference between the status quo and planned outcome is the fact that all of the above-declared external actors will be integrated into the Tezos Network, which would internalize current off-chain processes and decisions, and, by that, internalize control points.

Incentivization. To better understand the mutual dependence among the actors within Tezos, we study applied incentivization along the transactional, technology development, and organizational layer in the following; as all planned incentivization mechanisms seem already operational, we do not distinguish between status quo and planned outcome. As for the transactional layer, Baking peers are incentivized to accumulate XTZ, through own funds or delegation from non-baking peers, to higher one's chances to obtain the next mining reward. Non-baking peers have the monetary incentive to delegate their XTZ to a baking peer, as they receive a dividend in return. Consequently, more XTZ will be delegated to trustworthy bakers due to more secure earning opportunities. As a disincentive to baking peers, in the event of a misuse, the XTZ from the own deposit and collected as baking rewards are withdrawn and the baker is likely to lose the confidence of the delegators as well[15]. As for the technology development layer, at the same time, XTZ amount to decision-making say in the amendment process. So, baking peers also have the incentive to build and maintain a good reputation, as non-baking peers might shift their funds in case of disagreements. Aside from monetary incentivization, Tezos developers also strive for reputation. As for the organizational layer, the Tezos foundation monetarily incentivizes research and development of Tezos in general through grants.

Overview on DFINITY: Towards the (better) World Computer

DFINITY is a project, which was founded in early 2015. Against its Zeitgeist, DFINITY opted against a funding via ICO, supposedly not be associated with unregulated, possibly fraudulent projects, which were present at that time. Instead, DFINITY acquired approximately $167m[18], mainly from investors. DFINITY builds a proclaimed new generation of the internet relying on bundled, shared, and decentralized computational power. These objectives are pursued via a four-layered architecture[19]. As no Mainnet or Testnet were launched, no publicly available dapps have been created, yet. The organizational composition outside of the DFINITY Network consists of the DFINITY foundation (located in Switzerland; supervises development and maintenance; inheres funds and IPR; recruits and offers platform to developers), the DFINITY development teams, and investors. From a technical perspective, DFINITY relies on an own blockchain[20], a novel consensus algorithm, and an on-chain governance system labeled the DFINITY Blockchain Nervous System (BNS)[21]. The BNS inheres entire control over the network, for example, it can remove malicious actors from its system, put single hosted systems on hold, or dynamically change system-internal economic parameters such as its token-value. Interestingly, DFINITY dapps can run on Ethereum and vice versa. As a consequence, engineers can choose to host dapps on the former ("Code is Law"), or they choose DFINITY, which allows for dapp upgrades or transaction reversal, stemming from the distributed intelligence rendered possible on-chain by the BNS. The BNS is a decentralized web of connected so-called neurons. The placed stake can vary from neuron to neuron and so can the relative voting power and promised rewards. To demotivate market exploiters, the monetization of deposits from neurons takes over three months. Each neuron is able to vote on proposals with a strength relative to its staked value, and voting can be done either manually or automatically. Nonetheless, the BNS is only a theoretical construct and has not yet been tested in practice. We detail DFINITY's governance traits in the following.

Governance Traits of DFINITY

Coordination. To understand, how work is formalized, divided, and aligned in DFINITY, we now detail its actors along the transactional, technology development, and organizational layer. Within the status quo, on a transactional layer, there is no coordination analysis of the network and no proposal-voting process like in Aragon's or Tezos' network, as the BNS is not operational, yet. Instead, on the technology development and organizational layer, as we suppose, external contracting defines the current contract framework. The foundation is thereby a crucial coordinating actor since the foundation solely defines how resources are allocated and what is implemented by whom; the foundation thereby assigns and supervises work from development and research teams.

Similar to Aragon and Tezos, within the planned outcome, the influence of off-chain entities is planned to be downscaled once the system is fully running. While the coordinating role of the DFINITY foundation on the organizational and technology development layer would decrease, the future coordination of DFINITY would take place via on-chain consensus finding inside of the BNS. Three coordination mechanisms are seen as central to DFINITY: the (1) submission and examination of proposals, (2) voting, and (3) decision enacting. Similar to Aragon and Tezos, the BNS defines a sequence of steps as well as their outputs are standardized (standardizing of work processes/outputs).

Control. Here, we examine DFINITY's transactional, technology development, and organizational layer to understand, how control is exercised by whom within DFINITY. Due to the fact that DFINITY is not yet operational, we neglect the transactional layer in terms of control. As for the technology development and organizational layer, the current network consists of DFN holders only. Thereby, these holders do not have a direct control on the overall decision-making (unlike Aragon with its AGPP or Tezos with its amendment process). All other organizational building blocks are contemplated as external influencing factors. These include the (1) DFINITY foundation, (2) development bureaus, and (3) investors. The DFINITY foundation

[18] https://www.crunchbase.com/organization/dfinity-network, accessed February 26, 2019

[19] Identity (administrating new pseudonymous block miners; deposit required similar to PoS), Random Beacon (jointly produced verifiable, random function), Blockchain (probabilistic slot protocol (PSP)), and the notary (near-instant block finality) layer. Retrieved April 17, 2019, from https://dfinity.org/pdf-viewer/library/dfinity-consensus.pdf

[20] DFINITY does not claim to have an own blockchain per se, but to build an evolution of blockchain technology: https://dfinity.org/faq/is-the-internet-computer-a-blockchain

[21] The BNS ensures a coordinated way to maintain and enhance its system and consists of the phases of (1) proposal submission, (2) proposal evaluation and voting, and (3) decision enacting. As for proposal submission, proposals of any kind can be made on-chain in exchange for a deposit in dfinities (DFINITY's token); if approved, the deposit is returned, otherwise, the deposit will not be paid back. In the case of a refusal, the BNS does not vote on the suggested proposal at all and the proposing actor loses the placed security deposit. In case of adoption, the BNS votes on the proposal and the proposer has its security deposit returned. Similar to Tezos' delegation, the BNS provides a service that allows neuron-holding peers to define a follow list for each category. To improve its decision-making, intelligent algorithms parse through the follow lists and check in an order of precedence if one of the listed neurons already voted on this proposal or not. If this is the case, the voting decision of the followed neuron is adopted. Simplified, based on: https://medium.com/dfinity/the-dfinity-blockchain-nervous-system-a5dd1783288e

owns all rights to the system, manages all collected funds, and distributes them to development offices all around the world. Thus, the foundation not only controls funds but also its engineering bureaus.

As for the planned outcome, DFINITY plans a similar control mechanism to Aragon and Tezos. For one, as for the technology development and organizational layer, the BNS process also inheres a strong controlling next to its coordinating function. Here, development proposals are iteratively reviewed and voted upon; the network even will pay expert nodes to control the quality of proposals. In such a way, DFINITY allows users and experts to mutually control proposed developments.

Incentivization. To better understand the mutual dependence among the actors within DFINITY, we study applied incentivization along the transactional, technology development, and organizational layer in the following. As the system is not yet live, incentivization in the status quo on a transactional layer are not placed. On the technology development layer, token holders have the monetary incentive to hoard tokens, or to utilize the tokens to vote for changes to the system to their liking, which eventually serves their monetary incentivization. As for the organizational layer, the DFINITY foundation provides monetary incentivization (grants) to development teams to maintain and advance the system, while investors of DFINITY have the monetary incentivization to maximize their return on investment.

As for the planned outcome, several changes across all layers can be observed. As for the transactional layer, with the introduction of the BNS, DFN holders and neurons gain prominence, where neurons receive a mining reward for block validation or voting participation. As the probability for mining the next block corresponds with neurons at stake, the hoarding of DFN remains unchanged as main monetary incentive. This also holds true for the technology development layer, where neurons also act as (1) change proposers, (2) proposal evaluators, and (3) voters[22]. DFINITY thereby coupled the mining and voting procedures of neurons, which conflates system maintenance and altering. DFINITY thereby also plans to implement a reputation-based system labeled "trust-graph"[23], where a neuron's voting history is ongoingly evaluated; in order to maintain a high portion of staked DFN, and hence, to be trusted, neurons are incentivized to build a good reputation. Within a proposal to alter the current system, in addition to a non-refundable fee that acts as a payment to researchers for proposal evaluation and a refundable security deposit as disincentive against low-quality proposals, several formal requirements have to be met by the suggestion. These should create the incentivization for the proposer to prepare qualitative proposals such that the proposal-evaluating neurons get paid with their fee. Incentivization on the organizational layer is said to remain unchanged in the planned outcome.

Discussion

Our results have unpacked the complexity of DAOs, showing their main actual and planned novelties by depicting their applied coordination, control, and incentivization mechanisms, which answers RQ1. To prepare our discussion, we synthesize the cases' similarities and differences as follows:

- All of the cases in this study are frameworks that provide an infrastructure and tools to support the development and maintenance of dapps.
- Main internal actors are users, token holders, miners, and validators; the external ones are core-developers, project founders, leading figures, foundations as legal entities, and public authorities.
- A key coordination and control mechanism, that is planned in all cases to be automated on-chain, consists of suggestion of proposals, staking-based voting, and realization of decisions.
- The network tokens ANT, XTZ, and DFN are used both to maintain the system (higher chances of obtaining the next mining reward) as well as to alter the system; one's stake determines voting power.
- Currently, all cases are strongly affected by off-chain entities, especially by for-profit development teams, investors, researchers, and associations/foundations; the latter are central in terms of control.
- The operational systems of Tezos and Aragon seem to find little use in terms of the number of created dapps and active user/development accounts.

[22] In order to operate a neuron, a holder of DFN has to deposit a certain amount to the BNS. This amount is called a security deposit and determines the neurons' voting power and the proportionality of the earning rewards. This staking incentive applies to all types of neurons; with accumulative bad behavior, the value of the token might decrease in both the short- and long-term, which is why some owners might not retrieve their deposits in time for them to still be valuable. Retrieved April 17, 2019, from https://medium.com/dfinity/the-dfinity-blockchain-nervous-system-a5dd1783288e

[23] Retrieved April 15, 2019, from https://medium.com/dfinity/future-governance-integrating-traditional-ai-technology-into-the-blockchain-nervous-system-825ababf9d9

- All observed systems are stake-based and utilize delegated voting. So, there is risk that a plutocracy in the cards will be formed in which wealthy whales have the greatest decision-making power.

Where they differ (we only reflect here on the most striking differences):

- While Tezos' and DFINITY's endogenous governance happens at the protocol level, Aragon relies on governance structures on the dapp level; this is due to the lack of their own blockchain.
- Aragon's foundation explicitly intends to become a DAO itself, while others do not follow their credo to such a radical extend (dapp instead of DAO focus).
- Even though all of the cases use the blockchain technology as a backbone, their network objectives functionally diverge slightly (Self-governed DAO vs. Commonwealth vs. World Computer).

In the following, we derive learnings from our case observations by linking our main observations to associated concepts brought forward by our cases and the theoretical works introduced in chapter two. This forms this paper's theoretical contribution and, thereby, answers RQ2.

Off-Chain Centrality and Lack of Use. It is four years since TheDAO was launched, and numerous DAO projects followed and evolved. Against a persisting hype, our studied projects can hardly claim to have achieved decentralized governance nor autonomous organizing at the time of writing, as shown in the gap between their current and planned outcome. Given large funds and time at hand, this is a surprising outcome and it points towards inhibitors that could not be overtaken, yet. As for decentralization and autonomy, technical decentralization is in place in terms of dispersion of nodes or transactions validation rights for Tezos and Aragon[24]. Organizationally, however, central authorities are in charge or, at least, highly influential on core decisions such as fund allocations or technical decisions, which is the case in all observed cases. This is not only seen in their non-profits, which often hold IPR or funds, but also in the limited number of development teams, who centralize technological expertise, which is also a known issue in other blockchain projects (De Filippi and Loveluck 2016); similar to other blockchains, influential figures for each of the studied projects are known. Further, our studied DAOs' autonomy – in the sense of independence from off-chain influences –, seems to be limited, as each of these span a web of on-/off-chain entities, seen, e.g., in their development teams. According to the two ways forward for blockchain governance (Miscione et al. 2019), DAOs, at least for a certain time span, seem to combine both approaches, improved on-chain coordination and control while founding off-chain governing bodies; the latter are said to partly dissolve after bootstrapping its network and governance (in the case of Tezos and Aragon).

This all is not to say that DAOs are not progressing: Tezos only recently proved its on-chain amendment to work[25] and openly discusses ways onwards for their current system[26], while Aragon launched a first version of its digital jurisdiction[27] and its most influential figure resigned to foster decentralization[28], to say the least. What remains remarkable, however, is the significant effort on upfront design decisions to optimize governance structures, which is in line with other research (Miscione et al. 2019): a reductionist view on transaction cost efficiencies (Allen et al. 2020) oversees these development (production) costs (Garud and Munir 2008). At the same time, their blockchains seem to find little use, which is surprising given their financial possibilities, as these three projects alone combined a warchest of >$1bln in assets at their peak. One might doubt to be dealing with vaporware – i.e., announced software/hardware, which is never actually implemented but promoted for reputational purposes.

In open networks, such as FOSS, innovation (disruptive or not) comes from the fringes: given these DAOs' possibilities, it remains interesting, why these infrastructures did not originate generativity (Zittrain 2006), yet. Generativity does thereby not depend on capital but on large scale, free experimentation, where, out of countless efforts, very few successful services emerge. Then, because of positive network externalities, a winner tends to take all the organizational field. This is, hence, where one could argue these warchests to constitute a burden rather than an advantage: instead of experimenting freely on a large scale, legal issues and public feuds - well-exemplified by Tezos but also Aragon[29] and countless other ICOs - or token values became central. So, instead of legitimizing themselves on functioning governance, they swung for external

[24] Tezos: https://tezblock.io/account/list, Aragon: https://www.etherchain.org/charts/topMiners
[25] https://cryptobriefing.com/tezos-surges-successful-protocol-upgrade/
[26] https://medium.com/tezos/amending-tezos-b77949d97e1e
[27] https://cryptoticker.io/en/aragon-court-jurisdiction/
[28] https://blog.aragon.org/some-changes-at-the-aragon-association/
[29] https://thedefiant.substack.com/p/corrected-aragon-drama-pushes-on

legitimation, i.e. token's prices. In short, they exposed themselves to high market fluctuations beyond their own control, which they tried to tame with on-chain governance in the first place.

What (Who) are we building for? Aside from the question if blockchain use increases or not, governance is not independent from context, quite the contrary: context shapes the requirements, to which appropriate governance mechanisms are tailored to. For example, IT governance frameworks[30] first identify the context and then propose appropriate mechanisms to deal with these contexts. Consequently, without DAOs in use at scale, and without observable problems in practice, it remains unknown, if their upfront-developed governance mechanisms would match the future variety of a DAO's contexts. This problem recalls digital networks and their two-phase problem of growth: first they need to reach a critical mass to bootstrap by letting positive network externalities to kick in, i.e. users flock in and the network grows by itself. But then, when you have reached a certain scale, it becomes difficult to grow by adapting to different contexts for the simple reason that a large network opposes great inertia to changes (Hanseth and Lyytinen 2010). In other words, on-chain governance may preserve the network openness that promises to unleash generativity (Zittrain 2006), and tame it later on by modulating and tailoring uses onto desired outcomes according to its own 'constitution'. Ideally, this double-layered on-chain governance (put forward by Tezos and DFINITY) solves this problem (functionalities that allowed to reach a critical mass are hard to change later) by offering 'constitutional' rules agreed upon ex-ante. If this works in practice remains to be seen as due to the gap between the actual developments and planned outcomes. However, as seen in our findings, tokens are a financial means of compensation for miners, but also a speculative investment for others. Thus, a main problem across the blockchain domain is the increasingly professionalized investment infrastructure around cryptocurrencies consisting of day traders, institutional, private investors and many more whose interests may diverge from other parties more than on-chain governance mechanisms can accommodate. Indeed, many of these actors are not interested in the technology itself, but in the gains they might earn, which they could cash out in the extreme case of infrastructure collapses. It appears contradictory to have a token as a speculative investment while using it as the incentive for system maintainers: if a significant amount of investors decide to pull their funds from the project to another, the token's value decreases, which effectively affects mining rewards and, consequently, system security. A similar logic applies to our studied DAOs, whose assets, which are vital for the DAOs continual survival, are often stored in forms of cryptocurrencies (own or external), whose values fluctuate.

Reducing discretionality. A reductive view on DAOs as gatherings of smart contracts is misleading (Murray et al. 2019). As depicted in our study, DAOs are highly intricate, socio-technical ecosystems, which are shaped by a context of internal as well as growing and changing external interests. All of our observed DAOs are similar for their goal of substituting both never-ending conflicts and off-chain authorities with on-chain governance processes to coordinate the network decentrally, while still adhering to its stakeholders, specifically to its designers, users, and maintainers. The goal is, hence, to limit discretional human intervention – and, as such, opportunism - once the system is running. Thereby, the question arises, for which reasons are which functions planned to be on-chain? Most of the planned on-chain processes regard consensus on demand management, system architecture choices and code development, and transaction reversals, which is in line with problems seen in other blockchain projects (Ziolkowski et al. 2020) and it builds up on Bitcoin's/Ethereum's governance issues in the past (De Filippi and Loveluck 2016; DuPont 2017). The vision/dream of minimal and streamlined human intervention remains misplaced because, as soon as contingences put us out of our comfort zone, the ease to handle algorithmically knowns are replaced by known unknows and even unknown unknowns, which have been illustrated with the case of TheDAO (DuPont 2017). Therefore, these cases code rules "constitutionally" to change "law" code. For example, Tezos and DFINITY allow also to coordinate changes on-chain about the modality of coordination, funding, or others. Overall, the core idea of DAOs – marginalizing human intervention and automating processes – recall similarities to the cautionary tale of tightly coupled systems (Perrow 2011): while trying to mitigate risks by avoiding uncertainty, a malfunctioning of single parts may cascade through the entire system (Ziolkowski et al. 2020). Several of our interviewees confirmed the necessity of off-chain governance processes as a coordinated means of dealing with unforeseen situations. But of course, this brings discretionarily back in, and curbs the unleashed generativity of self-governed chains.

After linking related academic literature to our main empirical findings, we answer our research question two as follows:

[30] For example, COBIT: https://www.isaca.org/resources/cobit

- DAOs are no gatherings of smart contracts (Murray et al. 2019), but socio-technical ecosystems consisting of mutually dependent parties. Organizational processes are thereby increasingly ingrained and enacted on-chain, blurring the division between systems and organization (Miscione et al. 2019).
- Even though motivated by strong enthusiasm, funds, and beliefs, DAOs face several inhibitors to decentralization and autonomy; it remains interesting, why these projects have not originated generativity, yet. One could argue that these DAOs may become the victims of their financial successes where, instead of experimenting freely on a large scale, legal issues or public feuds take center stage.
- Human intervention in DAOs is being displaced, transformed, but not marginalized. Instead of achieving autonomy, our DAOs showed the reliance on several central actors acting as gatekeepers, administrate funds, or to accumulate expertise, which reintroduces trust into a system, which was repeatedly considered trust-free (Beck et al. 2016; Jarvenpaa and Teigland 2017).
- Shortcomings of "Code is law" (Lessig 1999) are met with "Code is Constitution", where our studied DAOs show mechanisms to change fundamental processes, when need arises. As a consequence, blockchain's immutability, one of its core characteristics (Zheng et al. 2017), is questioned.
- DAOs need to invest heavily up-front in governance structures, while their infrastructures find limited use, which draws similarities from studies on the Internet and their bootstrap problem (Hanseth and Lyytinen 2010). Without considering infrastructure in practice, these upfront costs pass unseen, while only promises of more efficient transactions through smart contracts are highlighted, as several authors argue (Allen et al. 2020; Meijer and Ubacht 2018).

Conclusion

This research studied three comparable and well-known DAOs, namely Aragon, Tezos, and DFINITY in terms of their applied coordination, control, and incentive mechanisms, to contribute to the growing research stream around blockchain governance and the underlying problems it addresses. Discussing the findings from our cases against a wider theoretical background confirmed the importance and extended our understanding of known concepts such as generativity, context, and in a wider sense, institutions.

This research is not free of limitations. First and foremost, our studied cases are partly still in development, which requires a follow-up study of their planned outcomes. While it is likely that core concepts will be implemented as promised, there is no guarantee, and other parts may not be implemented. Furthermore, governance, explicit or implicit, calcifies in practice and over time; we can only show a snapshot of these cases developments and plans at a given time. Further, there are many other DAOs, which are alike to our chosen cases. While we belief to have chosen relevant and well-documented cases, they certainly cannot represent all governance peculiarities DAOs bring about as, as we argued, governance is tied to context.

In conclusion, for further research, several lines could be considered. As we argue, blockchain organizing exceeds organizational boundaries while being originated in FOSS. The shared interest of multiple formally independent actors is thereby noteworthy and possible mechanisms to maintain their interests should be developed and studied, such as coordination, control, or incentivization mechanisms, but rather informal mechanisms like norms or trust, which proved explanatory for our cases. We encourage other researchers to continue to follow the development of our studied DAOs, especially in regard to how decision-making is taking place now that there is still informality in place in their online communities, blogs, or discussion sections, which, eventually, reflects their governance choices. Also, especially as seen in our cases, which often are reductively thought of as sets of smart contracts, it is worth considering whether those blockchain systems end up allowing users to have more influence on decisions, or if blockchain systems remain responsible only for what is automized by consensus algorithms. Finally, it could be illuminating to see if and how associations and central authorities go about their dissolution.

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